

A Review on AI-IoT-Based Intelligent Enemy Tank Detection and Tracking System

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Abstract: This paper provides a comprehensive review of existing AI- and IoT-based systems for autonomous detection and tracking of enemy tanks to improve situational awareness on the battlefield and provide convoy protection. Traditional manual surveillance involves high-risk and time-consuming operations for personnel; however, IoT integrated with embedded devices like the Raspberry Pi and ESP32, provides real-time acquisition, processing, and transmission of data with sensors, such as ultrasonic, infrared, metal, and vibration sensors. The identified studies in this review highlight the performance of several IoT-driven robotic systems that utilize wireless communication methods (Wi-Fi, GSM, LoRa) for remote observation/monitoring, and remote-control applications. Although several advances have been made, the majority of all identified systems are semi-autonomous, without AI decision-making based on multisensory fusion in addition to cybersecurity. This study identifies gaps in energy-efficient methods, secure methods for networking, and autonomous threat recognition. Potential pathways to address the gaps identified within this study include the incorporation of AI-enabled edge computing, blockchain-based communications, and swarm robotics for intelligent, resilient, and adaptive military surveillance systems.

Keywords: Internet of Things (IoT), Raspberry Pi, Military Convoy Protection, Sensor Networks, Real-Time Surveillance.

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I. INTRODUCTION

The movement of soldiers, supplies, ammunition, and medical supplies as part of a convoy system is a critical element of the logistical framework of defense in modern military operations. These convoys will typically operate in unsecured areas with unpredictable operational tempo and varied geography, with possible hazards of ambush, improvised explosive devices (IEDs), and other enemy environmental challenges. The conventional approach of placing a convoy for safety relies on human observation and human action. Further, the human actions are dependent on a person relying on specific factors such as fatigue, reaction time, and situational awareness. Furthermore, warfare continues to evolve through asymmetric competition,

technology, and posturing that leads to a desire for intelligent autonomous systems that will offer situational continuity, cognitive processing of data, and artificial intelligence to make informed decisions in real-time. Thus, when the Internet of Things (IoT) is incorporated with an embedded computing solution, such as a Raspberry Pi, it is a creative and plausible solution to convoy safety through threat specification and automated actions.

The Internet of Things (IoT) describes a number of interconnected devices which can independently collect, transmit to, and analyze data in real-time. IoT systems within defense can communicate information between vehicles, sensors, command posts and personnel, assisting enhanced decision-making capabilities and operational effectiveness. In

convoy protection scenarios, an IoT system provides an enhanced air awareness capability providing information/monitoring of surrounding vehicles, obstacles, tracking of convoy movement, and potential threats such as an explosive device or intruder. The Raspberry Pi is a small, affordable embedded computer used as a control and processing hub in such a system. The Raspberry Pi's processing capabilities, as well as its versatility to interface multiple sensors and execute highly complex algorithms, make it an ideal embedded computer for military-grade IoT

systems. Additionally, when paired with ultrasonic, infrared, detection of vibration and metal sensors, it is capable of interfacing with very powerful GPS and camera modules.

II. LITERATURE SURVEY

The summary of the survey on AI +IOT Based intelligent enemy tank detection and tracking system is presented in Table 1.

Table 1 summary of the survey on AI+IOT Based Intelligent Enemy Tank Detection and Tracking System is Presented in

Sr. No.	Paper / Authors	Method Used	Sensors Used	Technology Used	Component Separation
1	H. Li et al. (2018), "Attack Detection in Cyber-Physical	Particle Filter-based anomaly detection	Level sensors (three- tank system)	Cyber- Physical Systems (CPS), Control Theory	Sensors, Controller, Actuators, Network, Detection
2	F. Qi et al. (2021), "Sensor Fault Detection Based on Fractional- Order Chaotic System"	Fractional –order chaotic system for fault detection	Generic sensors with noise (industrial setup)	Chaos Theory, Fault Detection Fractional Calculus	Sensors, Chaotic Model, Fault Estimator, Controller
3	Q. Li et al. (2018), "Object Detection for High- Resolution SAR Images"	Spatial constraint –based object detection using SAR + Optical fusion	SAR sensors, Optical cameras	SAR Imaging, Image Fusion, Deep Learning	SAR Sensor, Optical Sensor, Image Fusion Module, Detection Model
4	W. Budiharto et al. (2019), "Development of Tank- Based Military Robot and Object Tracker"	Object tracking and robot navigation	Ultrasonic, IR, Camera sensors	Robotics, Embedded Systems, Object Tracking	Robot Base, Sensors, Controller, Motor Driver, Camera
5	S. Liu et al. (2022), "Remote Sensing Image Object Detection Based on Improved SSD"	Improved Single Shot MultiBox Detector (SSD) model	Remote sensing camera (satellite images)	Deep Learning, CNN, SSD Algorithm	Image Input, CNN Model, Detection Layer, Output Visualization
6	R. Girshick et al. (2016), "Region- Based Convolutional Networks (R-CNN)"	Region- based CNN for object detection & segmentation	Image dataset (no physical sensor)	Deep Learning, CNN, Computer Vision	Image Pre-processing, Region Proposal, CNN, Classifier
7	Wu et al. (2015), "Typical Target Detection in Satellite Images Using CNN"	CNN for satellite target detection	Satellite imaging sensors	Deep Learning, CNN	Image Dataset, CNN Feature Extractor, Classifier, Output Display
8	W. Budiharto et al. (2019), "Android- Based Wireless Controller for Military Robot"	Android - Bluetooth control for robot	Bluetooth module, Motor sensors	Embedded Systems, Android App, Wireless Control	Android App, Bluetooth Link, Robot Controller , Motors
9	Gupta & Gupta (2018), "Military Surveillance with Deep CNN"	Deep CNN for target detection	Camera sensors	Deep Learning, CNN, Image Processing	Camera, Image Dataset, CNN Model, Alert Module
10	Krizhevsky et al. (2012), "ImageNet Classification with Deep CNN (AlexNet)"	Deep CNN (AlexNet) architecture	Image dataset (ImageNet)	GPU Computing, Deep Learning, CNN	Image Input, Convolution Layers, Fully Connected Layers, Output

III. DESCRIPTION OF LITERATURE SURVEY

Developed an anomaly detection framework based on the particle filter method for cyber-attack detection in Cyber-Physical Systems (CPS) based on level sensors in the context of a three-tank control system that monitored abnormal amplitude changes in process data. The proposed approach was performed at the process-level to be able to determine the overall system components of the sensors, controller, actuators, network, and detection algorithm to determine a more precise fault location...[1]

The model combined a network of simple sensors being affected by a chaotic model as well as a traditional fault estimator and controller which was able to detect the sensor's abnormal behavior. They found that their work improved robustness against uncertainties compared to conventional linear models and improved fault diagnosis capabilities...[2]

Examined object detection in high-resolution synthetic-aperture radar (SAR) images using a SAR-optical image fusion approach that relied on spatial constraint-based methods. Using SAR sensors and optical cameras, the system facilitated feature enhancement in difficult terrain. Based on deep learning and image fusion methods the architecture of their model was designed with SAR sensors, optical sensors, an image fusion module, and a detection model...[3]

Demonstrated the design of a robot system in the format of a military robot with a tank-like format and of the ability to operate autonomously based upon object tracking and navigation. The robot acknowledged ultrasonic, IR, and camera sensors used to autonomously detect and then track moving objects. The object and navigation models were a combination of robotics and embedded technology, including a robot base, sensors, controller, motor driver, and camera...[4]

Introduced a revised version of the Single Shot MultiBox Detector (SSD) for properties in remote sensing images. Utilizing remote sensing optical satellite cameras, the work leveraged a deep learning architecture on a convolutional neural network (CNN) to improve detection speed and accuracy. The devised architecture consisted of four modules in total. These included a module for image input, CNN model, detection layer, and output visualization...[5]

Region-Based Convolutional Neural Networks (R-CNN) were proposed for object detection and image segmentation. The study focused on a dataset of images rather than a physical scenario with sensor data, yet was still underpinned on ideas of deep learning and computer vision. Classification of fast R- CNN and Mask R-CNN...[6]

The convolutional neural network-based framework presented the application of deep learning and CNN feature extraction techniques for classifying and recognizing different targets in high-resolution satellite images. There was a framework architecture comprised of an image dataset, a CNN feature extractor, a classifier, and output visualization, which

showed a robust detection of complex terrestrial targets and shown improvement compared to past manual methods used in remote sensing applications...[7]

The system took advantage of a communication method using Bluetooth modules, and a motion method using motor sensors. The system was based on embedded systems and Android App development. The system featured an Android App, Bluetooth link, a controller to move the robot, and various motors. The control system will work reliably, simply, and be adaptable to the field, and is a cost-effective and efficient way to do real-time navigation through a military robot...[8]

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AlexNet leveraged large-scale image datasets and deep learning using GPU processing power. The AlexNet architecture, with image input, convolutional layers, fully connected layer, and output classifier architecture, achieved state-of-the-art accuracy for object recognition and set a new standard or threshold for future CNN models, especially for both civilian and defense imagery analytics.[10]

IV. BLOCK DIAGRAM

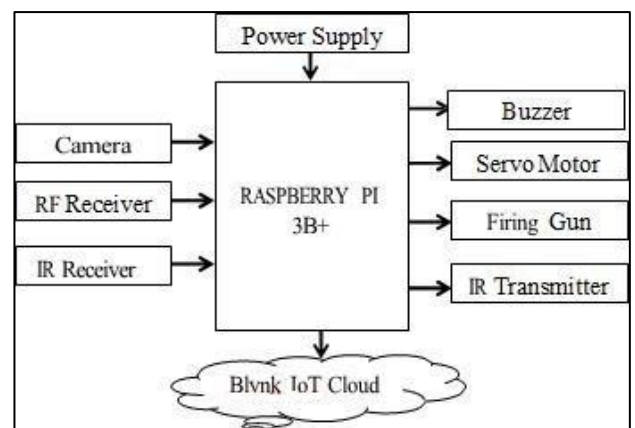


Fig 1 Block Diagramme of Designed Model of Transmitter

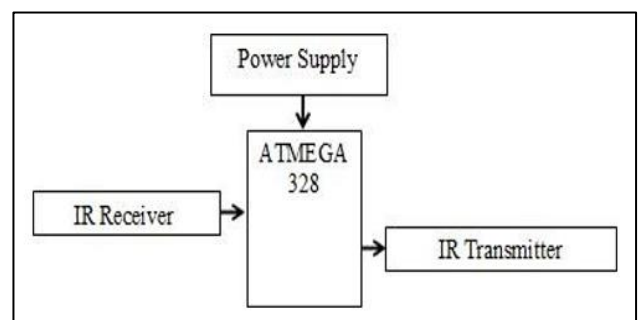


Fig 2 Block Diagramme of Designed Model of Reciever

➤ *Flow Diagram*

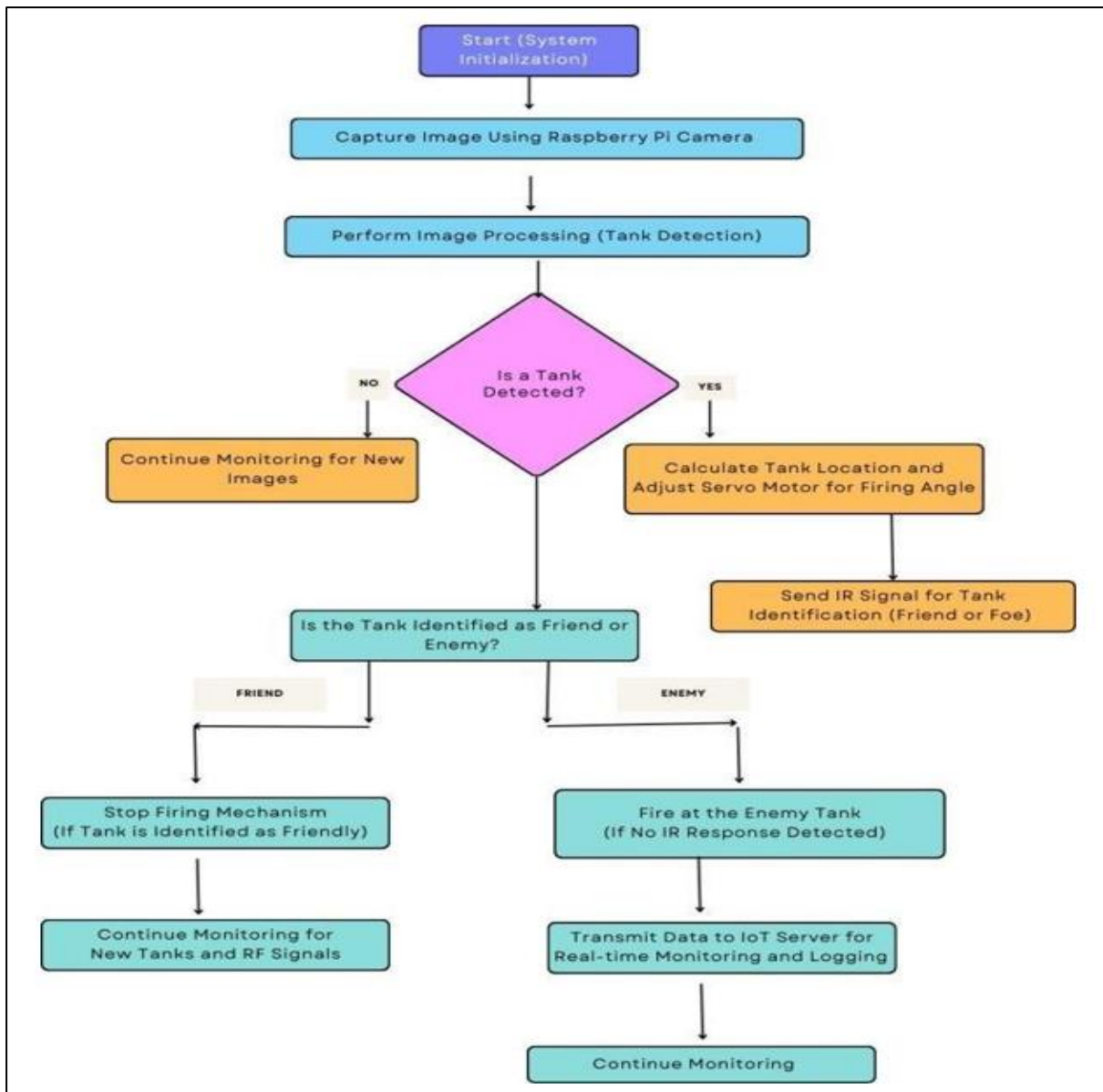


Fig 3 Flow Diagram

V. RESEARCH GAP AND DISCUSSION

The vast majority of reviewed studies monitored and/or surveilled, with most utilizing Raspberry Pi for live streaming video and manual or semi-automated control. While possible and low-cost, they mostly rely on people and have limitations due to a lack of advanced decision-making scripts. Without artificial intelligence (AI) or machine learning (ML) algorithms, there is limited capability for autonomous detection, identification, classification, or escalation of threats such as landmines (explosive devices), intruders, or hazardous environments. In addition, multisensor data fusion methods are unexplored methods for accurate target identification, which will reduce situational awareness and response time in complex environments. The second major gap is in communication and networking architecture of the systems. Most prototypes send their data via either Wi-Fi or GSM,

which cannot transmit data over as large a range and may become adversely affected and disrupted by interference or jamming. Virtually no studies used communication protocols with at least defense-grade encryption and authentication capabilities, such as LoRa, ZigBee, and secure mesh networks, that can facilitate long-range and redundant communication. Additionally, none of the studies engaged standardized encryption and authentication mechanisms to assure data integrity during transmission. By ignoring risks related to cyber insecurity, the research authors should be seriously concerned if data is intercepted or modified as it would potentially affect the entire mission.

From a hardware and energy management standpoint, most designs seem to prioritize working prototypes rather than sustained operational performance. Rarely are battery management, power expenditures, or self-recharging

evaluated when military convoys, for example, often operate in remote environments autonomously for a disproportionate number of hours. In addition, the environmental robustness of these systems, especially minimum or maximum temperatures, dust, or radiation, is rarely experimentally evaluated. There are deployed domains for these robotic platforms in the military domain when they are expected to operate dependably when they are reliant on the deployment for prolonged deployment time.

VI. CONCLUSION AND FUTURE SCOPE

The examination of the IoT-based military convoy protection system using Raspberry Pi indicates a technological shift from physical monitor methods previously used for convoy monitoring, to automated and intelligent, interconnected military defense systems. IoT sensors, embedded computing techniques, and on-site field communications provide many advantages to situational awareness and rapid-response in military operations. Connectivity via Raspberry Pi and ESP32 provides a low-cost participatory method of deploying surveillance robots with video cameras transmitting live video, in addition to ultrasonic, infrared, gas, and metal sensors. Like the system, many of the developments have room for improvement in terms of AI, power management, and secure vehicular communications, and remain semi-automated in a nature. The systems have been proven to work in a controlled setting, but require additional verification in real life conditions such as difficult mountainous terrain and hostile signal interference.

Future studies need to focus on improving the potential for vessels to autonomously interact to facilitate smart intervention within their convoy-protected environments. AI and machine learning can be implemented for immediate threat detection and object categorization, as well as alternative route navigation with little to no latency. Edge computing on Raspberry Pi nodes would be beneficial in reducing latency and establishing the best data transfer in a disconnected setting. Blockchain-based communications can be assessed against other data exchange options with an emphasis on confidential data integrity for data confidentiality and operational integrity. Long-range/low-power communication protocols (such as LoRa or mesh networking) will provide communication options to keep vessels in communication over extended missions. Unique to the implementation of swarm robotics, and multi-agent coordinated action, the convoy protection can happen all three levels of actions (e.g., intelligence gathering, visual indication, reactive plan).

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